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Their views and backgrounds
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Cover: CPC International subsidiary Enzyme Bio-Systems Ltd. uses state-of-the-art computer control in producing its line of high-quality industrial enzymes at Beloit, Wis., plant

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Cover Story

Industrial enzymes struggle to overcome commodity status of past few years; although consumption has gone up, the prices of some key enzymes have fallen. Page 11

Industrial Enzymes Battling To Remain Specialties

Consumption has gone up but prices of some key enzymes have fallen as they have suddenly slid into commodity status

Patricia L. Layman, C&EN London

With most segments of the chemical industry fighting to move from commodity to specialty products, the commercial enzymes business is no exception. Perhaps what makes the enzymes business stand out, however, is that it started out as what most people would call "specialty" and in the past five years has tumbled into commodity marketing, a label it is now struggling to overcome.

This, in brief, is the conclusion of London-based consultants L. Hepner & Associates, in a new study, *Industrial Enzymes by 1990—Specialties vs. Commodities*. An earlier study, which had looked at the industry as it stood in 1980, identified some 16 industrial enzymes, in a market of \$300 million. At the time, the consultants predicted that sales would reach \$500 million by 1985.

"Our estimates of consumption were right—that has gone up. However, we had assumed constant, level prices or an increase with inflation. And prices for some key enzymes have decreased," concedes Leo Hepner. In fact, the total market for industrial enzymes is now about \$400 million. And that takes in an expanded slate of 22 such enzymes, which Hepner and codirector Celia Male have defined as those items with sales of more than \$500,000 each.

What has gone wrong with the

enzyme business since 1980? The basic problem is that in one of the major markets—converting starches into ethanol, glucose syrups, and the like—enzymes have taken a sudden slide into commodity status, with serious price pressure. In 1980–81, the average price of enzymes was about \$12 to produce 1 metric ton of high-fructose syrup, including such "specialty" enzymes as high-temperature amylase, glucoamylase, and glucose isomerase. Now, it is about half that, about \$6.00 to \$7.00 to produce 1 metric ton.

At the time, says Male, the market was just large enough to support a certain number of producers. But with the spotlight on biotechnology, a number of new producers came in, with not surprising impact on the pricing structure. For example, starch conversion is the major end use for commercial enzymes, accounting for more than 50% of the market by volume. However, those sales had been going to companies who had the technology for producing those enzymes—that was always a threat.

The threat was made good, when large starch processors, such as ADM, Decatur, Ill., and CPC International, Englewood Cliffs, N.J.,

who had the technology for enzyme production—but either hadn't used it or who had underutilized capacity—came into the market, initially producing for captive use. The merchant market for other enzyme producers, therefore, shrank, and they lowered prices to try to retain sales. Instead of prices going up as predicted, they fell dramatically, although consumption of starch-conversion enzymes has seen real growth of about 5% per year.

Major enzyme suppliers still dominate the industry. Their market share has declined, however. For example, Novo, which is by far the largest supplier, has seen its market share slip over the past several years from nearly 50% to about 40%. Novo and Gist-Brocades used to control about 65% of the market between them; now Novo, Gist, and Miles Laboratories account for about 70% of the total. These three are major suppliers of starch-conversion enzymes and proteases for detergents.

Novo, Gist, and Miles, with their subsidiaries, make up a strong first tier of suppliers. Over the past five years, however, observe Hepner and Male, there has emerged a distinct second tier of companies, each

Commercial enzymes: who makes them . . .

	% of market
Novo Industri (Denmark)	35–40%
Gist-Brocades (Netherlands)	15–20
Miles Laboratories (U.S.)	5–10
Hansen (Denmark)	5
Sanofi (France)	5
Finnish Sugar (Finland)	5
All others	15
TOTAL	100%

Source: L. Hepner & Associates

. . . and how their markets are split

	Commodity	Specialty
Food applications, including starch, sweeteners, cheese, brewing, fruit, vegetables, baking, and confectionery	40%	15%
Industrial applications, including laundry detergents, paper, and leather	35	5
Animal feed/agriculture	3	2
TOTAL	78%	22%

Proteases lead industrial enzyme market in both volume and value

There are four major categories of industrial enzymes identified by consultants L. Hepner & Associates:

- **Proteases.** These are used primarily for detergents, to enhance stain-removal capabilities, and account for about 25% of the market.
- **Enzymes for starch conversion.** These are used for making corn syrups, for example, and for producing ethanol; about 20% of the total market.
- **Rennin.** These find use in the dairy industry for processing milk and cheese; about 10 to 15% of the market.
- **A miscellany** that includes such enzymes as pectinase for clarifying wines and other fruit juices, lipase for fat-splitting, papain for beer clarification, and invertase for confectionery.

The oldest techniques for producing enzymes have been variations of surface culture. Surface culture is relatively simple, using trays to hold a shallow amount of liquid, in which the microbial strain is cultured, and into which the enzyme metabolite is exuded. The technique needs a large surface area, as the metabolism needs air from the surroundings. In addition, it is very labor intensive, requiring frequent tray filling and emptying.

At present, there is only one large plant in the West for surface culture of industrial enzymes, owned by Novo's Swiss subsidiary Schweizer Ferment. "No one would dream of building one now on a big scale," says Cella Male, codirector of L. Hepner & Associates.

The technique is used for only true "specialty" enzymes, such as some pectinases, microbial rennins, and fungal amylase.

Most industrial enzymes are produced by submerged culture, originally adopted for penicillin in World War II. This culture is basically the same as that used for producing antibiotics (fermentation tanks, centrifuges, filters) involving batch processing. Feedstock is a carbon source, such as starch hydrolysates, molasses, or glucose, on which the organism, such as *Bacillus subtilis*, can grow. Other ingredients in the broth include a nitrogen source, such as corn-steeped liquor or cottonseed meal; mineral salts; and yeast extracts.

The medium is sterilized and the seed

accounting for about 5% of the market. Danish producer Hansen, which specializes in enzymes for the dairy industry as the leading supplier of rennin, has been a member of this group. But the Hepner study identifies two newcomers to the commercial enzyme market: Sanofi, the subsidiary of French oil and chemicals giant Elf Aquitaine, and Finnish Sugar Co.

Sanofi is a newcomer in dairy enzymes, having snapped up a number of small enzyme companies in the food industry, including Dairyland Food Laboratory, Waukesha, Wis. "If you add up all their market share in dairy enzymes, they are just below Hansen," says Hepner. The acquisitions still function as individual companies; they have not yet been pulled together as a central entity.

On the other hand, last year Finnish Sugar jumped in with a joint venture with Nabisco Brands, to produce starch-conversion enzymes. Finnsugar and Nabisco established Starch Processing Enzyme Co. (SPEC), to produce, among other starch-conversion enzymes, immobilized glucose isomerase for making high-fructose corn syrup. The marketing of the enzymes, based on technology originating from Nabisco Brands, is being handled by Fermco Biochemicals, Elk Grove Village, Ill., a wholly owned subsidiary

of Finnsugar. The enzymes are marketed in the U.S. and other parts of the world to major starch converters, such as ADM.

The third, bottom tier is made up of nearly 40 suppliers that share the remaining 15% of the market. It includes, among others, Pfizer—just a bit below the second tier—producing detergent enzymes in Mexico and amylase in Brazil as well as Japanese producers, none of which have large enzyme sales. The study, for example, notes 10 Japanese companies with total enzymes sales of about \$30 million among them.

The Japanese enzyme producers tend to concentrate on the relatively simple but labor-intensive technique of surface culture. U.S. and European producers, on the other hand, use the submerged-culture approach, which is similar to that used for producing antibiotics by batch processing. One of the major Japanese products is pectinase (used, for example, in the brewing industry), most of which is sold outside Japan and much of it to western companies. Japanese producers also use specialty fungal enzymes in their sizable domestic market for sake, miso, and soy sauce.

In the Hepner study, several new commercial enzymes were picked out for further investigation. Lipase is one of the more interesting new products, says Male, and is starting

to become a significant product for at least two applications. Microbial lipase helps age young cheese to a more mature flavor. Lipase also is beginning to find use for processing vegetable fats and oils. During transesterification, lipase helps modify fat composition. This enables manufacturers to take a cheap, commercially available fat such as palm kernel oil and convert it, for example, to a cocoa butter analog. "Some interesting companies—such as Unilever, Fuji Oil, and Henkel—are starting to look at enzymic fat modification," she says.

Another "new" enzyme is lysozyme, a bacteriolytic protein found in tears, saliva, egg white, and bacteriophage. It is used pharmaceutically because of its bactericidal properties, and now is being used in foods. Enzyme manufacturers also are looking at markets in the agricultural/dairy industry.

A possible market, for example, might be in milk from silage-fed cows. The milk can contain clostridial spores, which can cause spoilage in cheese, points out Hepner. European farmers, in particular, have become major proponents of silage, a lactic-acid fermentation product. There are several ways to treat spores. One, by nitrate, is allowed by West Germany and the Netherlands, but because nitrates can form nitrosamines, there is pressure to re-

culture is added. Fermentation proceeds for about two to three days with aerobic stirring. The classical technique, which provides the bulk of the business, is extracellular production by which the organisms exude the enzyme—their metabolite—into the broth. The key is to minimize the growth of cells and maximize the metabolite.

The yield is roughly 5% protein, a crude preparation but of commercial standard. Enzymes for pharmaceutical or diagnostic applications, however, need to have much higher purity, up to 95% protein.

Some of the more recently introduced enzymes are prepared by intracellular production, in which the key is to grow the biomass and then "reap" it—rupture

the cell walls and obtain the enzyme. In contrast to extracellular production, maximum cellular growth is desired. Enzymes from intracellular production are generally more difficult to make. Very few are used in the immobilized state. Chief among those that are is glucose isomerase, used in production of fructose from glucose.

There are already two generations of immobilized glucose isomerase. The first-generation isomerase features immobilized whole cells, in which protein crosslinking agents fix the cells together. The enzyme activity of the cross-linked cells is limited, however, to perhaps 20 to 30 cycles and then a new column is needed.

The second-generation glucose isom-

erase uses an improved process: The soluble enzyme is immobilized on an ion-exchange cellulose system. In essence, a technician can recharge the column by pouring soluble enzyme over it, which then binds onto the column. Within the past 18 months, Finnish Sugar Co. has landed in the second tier of suppliers of industrial enzymes, on the strength of its second-generation isomerase technology.

Miles Kali-Chemie, Hannover, West Germany, a joint venture of Miles Laboratories and the West German company Kali-Chemie, also has developed a second-generation isomerase. The whole point, says Male, is that "people aren't standing still. They are trying to upgrade their enzymes."

move them. The other way is by lysozyme, which is now permitted by authorities in Italy, France, and Denmark, with West Germany considered to be on the verge of allowing its use. At present, the enzyme is derived at high cost from egg white. Genetically engineered lysozyme, however, could be a commercially attractive product for producers, the study suggests.

Silage is also the market that has made cellulase a commercial product, the report says. It has been suggested that cellulase could be used to break down all cellulose wastes to sugars. Given the abundance of starch sources, that has not proved feasible. However, cellulase is being used as a silage additive. And Finnish sugar is promoting glucose oxidase as an additive for silage, to give a high-quality, high-protein product.

In fact, dairy and agricultural products seem to be the great new hope for enzyme marketers. The Hepner study, for example, cites other new applications for enzymes besides lysozyme in the dairy industry. There are applications for enzymes for barley, besides those already used to process barley for brewing; in feeds for poultry and young hogs. The Scandinavians, for example, are using β -glucanase to pretreat animal feed.

There are other potential market opportunities—in the environmen-

tal field, for example. One application is in waste treatment. The U.K.'s Imperial Chemical Industries has already developed cyanide hydratase for hydrogen cyanide waste. Finland and Sweden have been investigating the use of ligninase for the pulp and paper industry, seeking to exploit the fact that ligninases are also peroxidases. They degrade lignin and release the chromophoric groups from it, treating wood pulp in an "environmentally kind" way. Genetic engineering companies are working on these now to get commercially viable yields.

Conversely, both Hepner and Male are pessimistic about the chances of enzymes replacing chemical catalysts in reactions. For any chemical reaction, Male points out, an enzyme would have to match or better the reaction efficiency that chemical catalysts can obtain. It hasn't happened very frequently. The study cites one Japanese company that uses nitrile hydratase for making acrylamide from acrylonitrile. It hydrates the double bond, in a very specific enzymic reaction. Similarly, ICI uses dioxygenase enzyme for converting benzene to benzene *cis*-glycol for its polyphenylene production, but that has yet to become commercially attractive.

Even in growth fields, the en-

zyme market has not proved a gold mine for everyone. Corning last year withdrew from immobilized-enzymes production. It still owns one third of GenenCor, but it has sold a part of the ownership to Staley, as a new partner with Genentech. Corning had wanted to couple an enzyme like lactase to glass. "They were hooked on the technology possibilities," Male analyzes. "But there was no incentive for the users to pay more for immobilized enzymes than for soluble enzymes using the regular technology."

In general, the enzymes business is showing steady growth, which Hepner predicts will continue at slightly less than 5% per year through 1990 (real volume growth, based on 1986 dollars). Even use of starch-conversion enzymes will grow as high-fructose corn syrup, an increasingly important sweetener for foods and beverages, grows.

The U.S. market had a big spurt toward the end of the 1970s, and then began to taper off, although volume growth is continuing. In Europe, the food industry is stuck with high-fructose corn syrup quotas, set years ago at 250,000 metric tons and never revised upwards. In the U.S., by contrast, HFCS production is about 4 million metric tons.

Proteases have been under slightly less price pressure than starch-conversion enzymes, and their use

is continuing to grow. The main factor boosting proteases is liquid detergents in the U.S. Many detergents use enzymes to help boost cleaning, which some consumers feel is adversely affected because of low-phosphate content. Enzyme detergents account for about 30% of liquid detergents in the U.S. The Japanese market for detergent enzymes has expanded. The European market is mostly static, although in the U.K. a number of major brands have recently been reformulated with enzymes.

Hepner expects protease prices to hold, with no drastic declines barring any major firms from jumping into the protease business. If one of the large detergent producers were to begin making its own detergent enzymes, that would put massive pressure on the market. One potential worrisome development: European detergents giant Henkel has announced a joint-venture protease plant with Biochemie from Austria.

It was scheduled to come on stream in 1986-87, and started up in the past few months.

Throughout the industry, suppliers are working to upgrade their enzymes to give them specialties status, thus differentiating them from commodities that are subject to the same kind of price cutting that hurt starch-conversion enzymes.

In addition, they are looking at capacity utilization and yield improvement. As Hepner observes, "If a supplier can get yield improvement, that is equivalent to adding capacity. Any new company getting into the enzymes business would have to put up a new fermentation plant; these are high-cost and very capital-intensive. The investment might be warranted for an antibiotics fermentation plant. Return on assets is much higher for something like penicillin, because the world market for penicillin is much larger. Enzymes, on the other hand, are not that big a market." □

The belief that dollar sums are not the issue was confirmed by C&EN last week in discussions with various Indian sources. Said one, "We really are not that far off in the settlement amount." He says Carbide made an offer that reached \$400 million in August 1985, when a settlement seemed imminent. At that time, the Indian demands hovered around \$1 billion, at which point negotiations collapsed. Last January, Carbide came to a \$350 million agreement with U.S. lawyers representing the Bhopal victims. But the Indian government, never having been part of those negotiations, scorned the offer. Time moderated tempers, however, and India, say reliable sources, now will be satisfied with \$500 million spread over seven to 10 years. Now the two sides must be brought together to end the whole battle.

"Neither India nor Union Carbide know of any process by which a dialogue can be initiated whereby both sides can save face," explains Shrivastava. "We think a forum is needed, and I am working on ideas on how such a meeting could be initiated."

Shrivastava has recently returned from Bhopal and New Delhi where he met with officials to lay early plans for a mediation effort. A few days ago he breakfasted with Union Carbide chairman Warren M. Anderson to broach the idea of the initiative. "I met him only for the first time," says Shrivastava, "but he seemed anxious to pursue the whole thing. Even though I've written and said a lot of things critical of him, I was still very impressed with his sincerity and concern for the victims. In fact, in some cases the level of concern he showed was higher than that of many of the politicians I met in Bhopal and New Delhi."

Last week Shrivastava was completing a 14-page mediation proposal. It will go to principals at Carbide and to officials in the governments of India and Madhya Pradesh, the Indian state where Bhopal is located. The aim is to bring both sides together in December. He does not feel lawyers can handle the mediation because the case is now in the Indian court system and legal protocol conspires against that route.

Efforts toward Bhopal settlement pick up steam

From the shape of the news concerning the ongoing saga of Bhopal, the two sides—the Indian government and Union Carbide—seem poised to square off in the court battle that is set to take place in Bhopal itself. India has just filed its affidavit in Bhopal district court. The amount of damages are unspecified; Indian sources have said a specific dollar figure required by the court will be given in some months, once various studies are finished. Behind the scenes, however, another scenario appears to be taking shape, one aimed toward settlement.

To recap the Bhopal toll, more than 2000 are dead—the "more" probably numbering about 1500, since even today an average of two persons exposed to the methyl isocyanate (MIC) gas are dying each week and a few hundred may simply be unaccounted for. In addition, India says another 500,000 have claimed injury from exposure to the gas that spurted from the tank at Carbide's pesticide plant the morning of Dec. 3, 1984. There is debate about the long-term toxicological and genetic impact of MIC, but in-

testinal problems, lung damage, and mental disorders are facts of life for thousands.

The current mood around the community of litigants and interested parties in this aftermath stage is that neither side wants to go through an Indian trial. Some believe that only a trial will serve to bring out the truth about what happened that night. But a decision, Indian sources now say, would take at least five years, and could take 15. The process would be costly, and information unflattering to both sides would probably emerge. Thus, a serious independent effort toward settlement has now begun.

Says Bhopal-native Paul Shrivastava, now an associate professor of management at New York University's Graduate School of Business Administration, "All the Indians want is a face-saving offer to demonstrate to their people that they are not selling out. The amount of settlement is not the real source of dispute. What Union Carbide has offered and what India expects are not that much different. India is not interested in any lump sum."

The latest public update on the Bhopal situation, at which some hints of settlement eked forth, came 10 days ago at an international conference on industrial-crisis management organized by Shrivastava at New York University. Carbide's Anderson, who has lived full time with the disaster, was a major participant and seemed eager to come to a settlement. In the audience of mainly academics were several critics of Carbide.

In his presentation, Anderson made a point of stressing as he has in the past that Carbide was not interested in any protracted trial. "My feeling about litigation was stated right from the word go," he said. "If you want to litigate victim liability I'll take as long as it takes to do it. But I want to avoid that issue. I accept moral responsibility."

"Our name was associated with that operation. People were hurt. Let's solve that problem. Let's not get caught up in this morass of litigation and responsibility because an individual might want to know 15 years from now what exactly did happen and who was to blame."

Anderson's presentation was an overview of Carbide's response to both the Bhopal disaster and the aldicarb oxime leak at its Institute, W.Va., plant just nine months later. He again repeated why he feels sabotage was the main cause of the Bhopal accident. He said Bhopal made corporations much more careful about seeking technology transfer agreements with Third World countries. And he called for what would essentially be no-fault global standards covering compensation for industrial disasters so that litigation can be avoided.

Carbide is more certain than ever, Anderson said, that entry of water into tank 610 containing MIC was a deliberate act. When the company studied core samples taken from the tank after the leak, "we avoided completely this issue of sabotage. We attributed no political overtones to this whatsoever, but we discounted any sequence of events that possibly could have introduced water to that tank other than a deliberate act. Now, lots of time has gone by, and we have now been able to look at logs and talk to some peo-



Anderson: avoid protracted trial

ple. Our conclusions remain that a large amount of water was in fact added to that tank, and it was deliberately done so by a disgruntled employee. We are not finished with our work there. The information we get will be shared with the Indian government when it's appropriate."

Anderson was quickly challenged on several points by the commercial consul for the Indian Consulate in New York City, Talmiz Ahmad. "Mr. Anderson has made the point that Union Carbide offered a generous settlement," Ahmad said. "Nothing could be further from the truth. They offered at different times five separate settlements of differing character. Which of these is generous we are at a loss to find out. But they are significantly lower than what the Indian government authorities including Air India have paid to their own victims from time to time. And that was without regard to questions of liability."

"He has suggested that the Indian government wanted the trial in the U.S. because of attractions of multibillion dollar compensations. I can assure the assemblage here that at no stage had we thought in terms of billions of dollars. And he is aware that the Indian government's claim has been significantly lower than \$1 billion and in fact is only slightly more than Carbide's last offer to us. But it has been in-

terested in prolonging this litigation and in continuing this problem."

Another Anderson critic was Charles Perrow, a Yale University sociologist who has been focusing studies on industrial disasters. "Union Carbide tried to present themselves as victims of something as simple as the Johnson & Johnson Tylenol case. They are saying somebody came along and sabotaged our plant and it really wasn't our fault. They are also saying that it was quite a different situation than at Institute. It's not."

"The question isn't how the water got in. Water can always get into anything. The problem is how you design things for what happens when water does get in. There would have been no severe explosion if the refrigeration unit had not been disconnected, or the gauges had been properly working and had been monitored by the personnel. There would have been less of a disaster if various actions were taken at the first smell of MIC, or if the scrubber had been large enough to handle a large excursion, or if the scrubber had even been in service, or if the water sprays had been designed to go high enough to douse the emission, or if the flare tower had been of sufficient capacity to handle a large excursion that you might expect from a large tank."

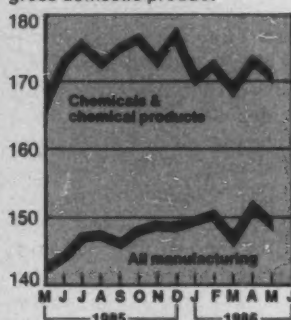
"That's a long list of deficits. Sabotage may be the most reasonable explanation for the water getting into that tank. But it's the most inconsequential part of the accident."

What is not inconsequential, however, is the move toward a settlement. When interviewed at the conference, Carbide officials were reluctant to clarify how the sabotage issue could affect the legal proceedings. Ronald S. Wishart, vice president for public relations, observed how "symbolism" is playing a powerful role in how the two sides relate. Shrivastava could well be the type of person who could act as the "credibility symbol" needed. He relates well to the Carbide executive team. He is an Indian native. He was a neighbor of some of Bhopal's victims. Currently he is working at it and doing the Hindu equivalent of keeping his fingers crossed.

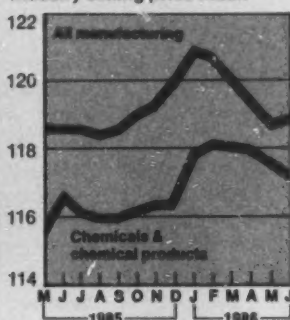
Wil Lepkowski, Washington

Canada's Slowing Economy Hits Chemicals

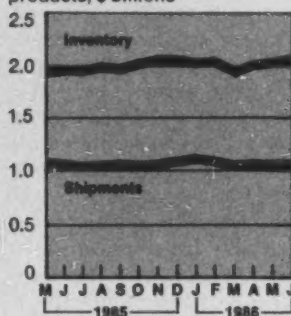
Volume index, gross domestic product^a



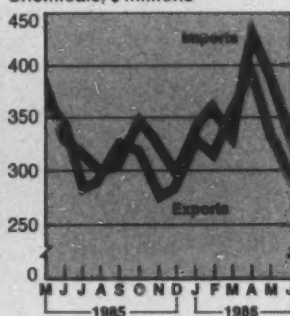
Industry selling price index^b



Chemicals and chemical products, \$ billions^c



Chemicals, \$ millions^c



^a Seasonally adjusted, 1971 = 100. June 1986 data not available. ^b 1981 = 100. ^c For 1985, \$1.00 = \$1.36 Canadian; for 1986, \$1.00 = \$1.40 Canadian. Source: Statistics Canada

Ethylene, polyethylene are only big gainers

Production, thousands of metric tons	1985	First six months 1986	1985	% change 1985-86
ORGANICS				
Ethylene	1744	942	842	11.9%
Propylene	648	276	307	-10.1
Benzene	688	298	317	-6.0
Toluene	473	167	231	-27.7
Xylene	415	165	208	-20.7
PLASTICS				
Polyethylene, low density	733	433	341	27.0
Polyethylene, high density	229	119	116	2.6
Polystyrene ^a	178	94	91	3.3
INORGANICS				
Hydrochloric acid	158	74	76	-5.1
Nitric acid	1128	585	571	2.5
Phosphoric acid ^b	627	342	332	3.0
Sulfuric acid	3890	1959	2000	-2.1
Ammonia, anhydrous	3620	1933	1737	11.3
Ammonium phosphate	1301	710	691	2.8
Chlorine	1424	744	700	6.3
Sodium hydroxide	1589	816	778	4.9

^a Includes acrylonitrile-butadiene-styrene. ^b 100% P₂O₅. Source: Statistics Canada

Although sales and earnings were up for most Canadian chemical companies during the first half of the year, chemical company executives know that their worries are not behind them.

With the exception of ethylene and low-density polyethylene, gains in Canadian chemical production have been far from spectacular. In fact, output is down for many key products.

First-half chemical exports—so vital for many of the major petrochemicals produced in Canada—are down. Chemical imports, meanwhile, are up.

To make matters worse, the Canadian economy is slowing down. The big question now is: What lies ahead? Some Canadian economists say their economy will perk up again in 1987. Others believe a recession lies ahead.

Canada is now in its fourth year of economic expansion, but the economy is losing some of its steam. Consumer spending, which helped carry the Canadian economy recently, is tapering off. Capital spending is down, particularly in the oil sector, which has been hit hard by low oil prices.

The chemical industry, however, is increasing its capital spending this year more than 50% to \$930 million (\$1.00 = 1.40 Canadian dollars, average for first six months of 1986), according to Statistics Canada. Most of this investment is going into ammonia, hydrogen peroxide, and sodium chlorate plants.

Statistics Canada also notes a slowdown in manufacturers' shipments over the past few months. For the chemical industry, midyear shipments weren't appreciably higher than they were a year ago and they are down about 3% from January. Chemical inventories, meanwhile, have inched upward slightly.

With so little momentum in the economy at home, some Canadian economists believe that trade will be a critical factor in determining which way the economy turns. Unfortunately, overall Canadian trade was weak in the first half. That certainly is true of chemicals. First-half chemical exports dropped 4.9% (based on Canadian currency), while chemical imports rose 8%. As a result, last year's \$109 million surplus in chemical trade was transformed into a \$161 million deficit this year.

The lower chemical exports reflect poor prices and depressed export markets. This is especially true of the U.S., which gobbles up two thirds of all Canadian chemical exports. The increase in Canadian chemical imports was spread evenly across the board, with the exception of fertilizers. Biggest gainers, however, were specialty chemicals such as toiletries and drugs.

If the U.S. economy rebounds, Canadian exports, including chemicals, probably will improve and give the overall economy a much-needed boost.

Earl Anderson, New York